ARAC WG Report
Protection of fuel tanks in a minor crash landing
FAR/JAR 25.963(d), 25.721, and 25.994
June 12, 2000

Category 3

1 - What is underlying safety issue to be addressed by the FAR/JAR?

To protect fuel tanks from rupture during a minor crash landing.

2 - What are the current FAR and JAR standards relative to this subject?

Current FAR text:

§ 25.963(d) Fuel tanks within the fuselage contour must be able to resist rupture, and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in Sec. 25.561. In addition, these tanks must be in a protected position so that exposure of the tanks to scraping action with the ground is unlikely.

§ 25.721 General
(a) The main landing gear system must be designed so that if it fails due to overloads during takeoff and landing (assuming the overloads to act in the upward and aft directions), the failure mode is not likely to cause--
(1) For airplanes that have a passenger seating configuration, excluding pilots seats, of nine seats or less, the spillage of enough fuel from any fuel system in the fuselage to constitute a fire hazard; and
(2) For airplanes that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, the spillage of enough fuel from any part of the fuel system to constitute a fire hazard.
(b) Each airplane that has a passenger seating configuration excluding pilot seats, of 10 or more must be designed so that with the airplane under control it can be landed on a paved runway with any one or more landing gear legs not extended without sustaining a structural component failure that is likely to cause the spillage of enough fuel to constitute a fire hazard.
(c) Compliance with the provisions of this section may be shown by analysis or tests, or both.

§ 25.994 Fuel system components.
Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway.

Current JAR text:

JAR paragraph 25.963(e) is identical to FAR paragraph 25.963(d). JAR 25.963(d) reads as follows:

(d) Fuel tanks must, so far as it is practicable, be designed, located and installed so that no fuel is released in or near the fuselage or near the engines in quantities sufficient to start a serious fire in otherwise survivable crash conditions. (see also ACJ 25.963(d).

JAR paragraph 25.721 is identical to FAR § 25.721 and JAR 25.994 is identical to FAR 25.994.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

The JAA has an ACJ 25.963(d) to require additional items under a broad interpretation of JAR 25.963(d) and JAR 25.721. In addition Certification Review Items have been use to provide additional criteria.

The FAA has imposed fuel inertia loading condition on tailplane tanks outside the fuselage contour by use of a Special Condition:

> Tailplane Tank Emergency Landing Loads. In addition to the requirements of § 25.963(d), the following applies;
> (a) The tailplane tank in the horizontal stabilizer must be able to resist rupture and to retain fuel, under the inertia forces prescribed for the emergency landing conditions in § 25.561.
> (b) For the side load condition the quantity of fuel need not exceed 85 percent when determining pressure loads outside the fuselage contour for the 3g lateral direction.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The main difference derives from JAR Paragraph 25.963(d) and the interpretations for 25.963(d) in ACJ 25.963(d).

ACJ 25.963(d) provides that the tanks outside the fuselage but inboard of the landing gear, or adjacent to the most outboard engine support the emergency landing loads of 25.561. All tanks outside the fuselage contour are assumed to be 85 percent full.

ACJ 25.963(d) also provides that fuel tank installations should be such that the tanks will not be ruptured by the airplane sliding with its landing gear retracted, nor an engine mounting tearing away.

4 - What, if any, are the differences in the current means of compliance?

ACJ 25.963(d) and a JAA Certification review items provide the means of compliance with 25.963(d) and also impacts 25.721 and 25.994. This includes fuel inertia loading for tanks outside the fuselage contour, considerations of sliding on the runway with combinations of landing gear not extended, additional landing gear breakaway criteria, and conditions of nacelles breaking away.

In compliance with the ACJ interpretation of JAR 25.963(d) the US manufacturers have used a chordwise head to determine fuel pressure under emergency landing load factors. The European manufacturers have used 85 percent of the maximum permissible volume

5 – What is the proposed action?

For each proposed change from the existing standard, answer the following questions:

6 – What should the harmonized standard be?

1. Amend Section 25.561 by revising paragraph 25.561 (c) to read as follows:

(c) For equipment, cargo in the passenger and cargo compartments, and any other large masses, the following apply:

(1) * * * * *

(2) When such positioning is not practical (e.g. fuselage mounted engines or auxiliary power units) each such item of mass shall be restrained under all loads up to those specified in paragraph (b)(3) of this section. The local attachments for these items should be designed to withstand 1.33 times the specified loads if these items are subject to severe wear and tear through frequent removal (e.g. quick change interior items). Cargo in cargo compartments located below or forward of all occupants in the airplane need comply only with c(1)(ii).

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2. Amend Section 25.721 to read as follows:

(a) The landing gear system must be designed so that when it fails due to overloads during take-off and landing the failure mode is not likely to cause spillage of enough fuel to constitute a fire hazard. The overloads must be assumed to act in the upward and aft directions - in combination with side loads acting inboard and outboard up to 20% of the vertical load or 20% of the drag load, whichever is greater.

(b) The airplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway, under the following minor crash landing conditions:

(1) Impact at 5 fps vertical velocity, with the airplane under control, at maximum design landing weight, all gears retracted and in any other combination of gear legs not extended.

(2) Sliding on the ground, all gears retracted up to a 20° yaw angle and as a separate condition, sliding with any other combination of gear legs not extended with 0° yaw

(c) For configurations where the engine nacelle is likely to come in contact with the ground, the engine pylon or an engine mounting must be designed so that when it fails due to overloads (assuming the overloads to act predominantly in the upward direction and separately predominantly in the aft direction), the failure mode is not likely to cause the spillage of enough fuel to constitute a fire hazard.

3. Amend Section 25.963 by revising paragraph 25.963(d) to read as follows:

(d) Fuel tanks must, so far as is practical, be designed, located, and installed so that no fuel is released, in quantities sufficient to start a serious fire, in otherwise survivable emergency landing conditions; and:

(1) Fuel tanks must be able to resist rupture and to retain fuel under ultimate hydrostatic design conditions in which the pressure P within the tank varies in accordance with the formula:

P=0.34*K*L

Where__

P = fuel pressure in psi at each point within the tank

L = a reference distance in feet between the point of pressure and the tank farthest boundary in the direction of loading..

K = 4.5 for the forward loading condition for fuel tanks outside the fuselage contour.

K = 9 for the forward loading condition for fuel tanks within the fuselage contour

K = 1.5 for the aft loading condition

K = 3.0 for the inboard and outboard loading conditions for fuel tanks within the fuselage contour

K = 1.5 for the inboard and outboard loading conditions for fuel tanks outside of the fuselage contour

K = 6 for the downward loading condition

K = 3 for the upward loading condition

(2) Fuel tank internal barriers and baffles may be considered as solid boundaries if shown to be effective in limiting fuel flow.

(3) For each fuel tank and surrounding airframe structure, the effects of crushing and scraping actions with the ground should not cause the spillage of enough fuel , or generate temperatures that would constitute a fire hazard under the conditions specified in §25.721(b).

(4) Fuel tank installations must be such that the tanks will not be ruptured by an engine pylon or engine mounting or landing gear, tearing away as specified in 25.721(a) and (c).

4. Amend Section 25.994 to read as follows:

Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in § 25.721(b)

7 – How does this proposed standard address the underlying safety issue (identified under #1)?

- The proposed change to 25.561 would ensure fuel tanks would be protected from cargo shifting in the cargo compartment under emergency landing condition.
- The changes to 25.721(a) ensure that the conditions of landing gear tearing away are considered with reasonable level of side load condition, in addition to the upward and aft loads.
- The changes to 25.721(b) cover gear up combinations..
- The emergency landing load factors were established for solid mass items in the fuselage and bear little relevance to fluid in tanks especially external to the fuselage. Fuel pressure loads would be determined by an alternative set of factors rather than the emergency landing load factors which would achieve the same design level as already achieved in the operational fleet
- Certain pressure design factors (e.g. forward condition) for tanks outside the fuselage would be ½ of those on the inside of the fuselage. The calculated pressures would consider a full head rather than the chordwise head and all tanks would be considered full.

- A decent rate of 5 fps for the "minor crash landing" condition is established for the purpose of protecting fuel tanks.
- The conditions of landing with any gear combination not extended are clarified in 25.721 to require all gears retracted and any other combination of gear legs not extended.
- The conditions for landing gear breakaway in 25.721 are also clarified.
- Nacelle breakaway conditions are added to 25.721
- The minor crash landing condition is clarified for section 25.994 by referencing 25.721.
- Consideration of thermal effects is added to 25.963(d)

8 – Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

An increase in the level of safety because it adds fuel tank pressure load criteria to fuel tanks outside the fuselage contour, provides additional break-away criteria for nacelles, and a requirement to consider fuel tank heating.

9 – Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

Same or slight increase since much of the proposed criteria have been achieved by certification review items, equivalent safety findings, and for tail tanks, by Special Condition.

10 – What other options have been considered and why were they not selected?:

For the fuel tank pressure load criteria, the working group considered several options including a full pressure head criterion using the 25.561 load factors with a partially full tank (85 percent) and a chordwise head criterion with a full tank. Neither of these criteria was considered acceptable because they applied simplistic inertia load factors, derived for fixed mass objects in the fuselage, to a fluid outside the fuselage. In the end, it was decided to use fuel tank pressure factors for the tanks outside the fuselage that would achieve the current fleet strength levels for tanks outside the fuselage. The factors for tanks, inside the fuselage, were adjusted to ensure that they would not provide lower loads than the existing standards.

11 - Who would be affected by the proposed change?

The revised rule would be applicable to new airplanes for which the application for type certificate is received after the effective date.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

Much of the proposed rule text is based on existing ACJ advisory material and certification review items. See the attached NPRM.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

There is no existing FAA advisory material, AC 25-963-2 and corresponding ACJ is proposed and is attached.

14 - How does the proposed standard compare to the current ICAO standard?

The current ICAO standard has no specific criteria for fuel tank protection.

15 - Does the proposed standard affect other HWG's?

No.

16 - What is the cost impact of complying with the proposed standard

Economic analysis still to be done but it is expected to be small in comparison to standard industry practice.

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

Advisory Circular AC 25.783-1A is submitted with full consensus of the working group

18.- -Does the HWG wish to answer any supplementary questions specific to this project?

Not at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

Yes